ESTIMATION OF AN OPTIMAL STIMULUS AMPLITUDE FOR USING VESTIBULAR STOCHASTIC STIMULATION TO IMPROVE BALANCE FUNCTION

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Introduction: Sensorimotor changes such as postural and gait instabilities can affect the functional performance of astronauts when they transition across different gravity environments. We are developing a method, based on stochastic resonance (SR), to enhance information transfer by applying non-zero levels of external noise on the vestibular system (vestibular stochastic resonance, VSR). The goal of this project was to determine optimal levels of stimulation for SR applications by using a defined vestibular threshold of motion detection.

Methods: We compared perceptual threshold (using a joystick) with that obtained from six measures of body sway (medio-lateral shear forces and roll moments, accelerations of head and torso, and roll velocities of head and torso). Following which subjects did a balance task in which they had to stand on 10 cm thick medium density foam and try to maintain balance, while they experienced stimulation from 20% to 400% of their perceptual threshold. Optimal stimulation amplitude was determined to be the one which showed the maximum improvement in balance performance when compared to the control (no stimulation).

Results: Comparisons of threshold of motion detection obtained from joystick data versus body sway suggests that perceptual thresholds were not different from body sway thresholds using force plate and head-mounted IMU, but were lower than that obtained from a torso-mounted IMU. But, body sway measures are affected more by systemic noise, or if the subject is stiff or fidgety. Results from the balance task shows that, in general, using stimulation amplitudes at 40% of perceptual-motion threshold significantly improved the balance performance.

Discussion: We hypothesize that VSR stimulation will act synergistically with sensorimotor adaptability (SA) training to improve adaptability by increasing utilization of vestibular information, and therefore will help us to optimize and personalize a SA countermeasure prescription to each crewmember. This combination may help to significantly reduce the number of days required to recover functional performance to preflight levels after long-duration spaceflight.

Learning Objective: Advancing the understanding of stochastic resonance mechanism in improving balance function.